EAST Search History

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L2	385	374/137.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2006/06/14 17:53
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Fused quartz

From Wikipedia, the free encyclopedia

Fused quartz or **fused silica** are types of glass containing primarily silica in amorphous (non-crystalline) form. It is manufactured using several different processes.

Fused quartz is made by melting high purity naturally occurring quartz crystal at around 2000°C using either an electrically heated furnace (electrically fused) or a gas/oxygen fuelled furnace (flame fused). Fused quartz is normally transparent.

Fused silica is produced using high purity silica sand as the feedstock, and is normally melted using an electric furnace, resulting in a material that is translucent or opaque. (This opacity is caused by very small air bubbles trapped within the material.)

Synthetic fused silica is made from a silica-rich chemical precursor, resulting in a transparent glass with an ultra-high purity and improved optical transmission in the deep ultraviolet. This material was originally called **fumed silica** because the high purity manufacturing process involves chemical gassification of silicon, oxidation of this gas to silicon dioxide, and thermal fusion of the resulting dust.

The optical and thermal properties are superior to those of other types of glass due to its purity (or rather, its lack of impurities). For these reasons, it finds use in situations such as semiconductor fabrication and laboratory equipment. It has better ultraviolet transmission than most other glasses, and so is used to make lenses and other optics for the ultraviolet spectrum. Its low coefficient of thermal expansion also makes it a useful material for precision mirror substrates.

Contents

Chemistry

Fused quartz is a noncrystalline form of silicon dioxide (SiO_2), which is also called *silica*. (The crystalline form of this material is quartz).

Applications

Specially prepared fused silica is also the key starting material used to make optical fiber for telecommunications.

Because of its strength and high melting point (compared to ordinary glass), fused silica is used as the envelope of halogen lamps, which must operate at a high envelope temperature to achieve their combination of high brightness and long life.

The combination of strength, thermal stability, and UV transparency makes it an excellent substrate for projection masks for photolithography.

Fused quartz has nearly ideal properties for fabricating first surface mirrors such as those used in telescopes. The material behaves in a predictable way and allows the optical fabricator to put a very smooth polish onto the surface and produce the desired figure with fewer testing iterations.

Translucent fused silica is used to make crucibles, trays and other containers for use in high temperature thermal processing, which are chemically inert to to most elements and compounds including virtually all acids, regardless of concentration. Translucent tubes are commonly used to sheath electric elements in room heaters, industrial furnaces and other similar applications.

Physical properties

The extremely low coefficient of thermal expansion accounts for its remarkable ability to undergo large, rapid temperature changes without cracking.

"UV grade" synthetic fused silica (sold under the tradename *Suprasil*) has a very low metallic impurity content making it transparent deeper into the ultraviolet. An optic with a thickness of 1cm will have a transmittance of about 50% at a wavelength of 170 nm, which drops to only a few percent at 160 nm. However, its infrared transmission is limited by strong water absorptions at 2.2 μm and 2.7 μm.

"IR grade" fused quartz (tradename *Infrasil* and others) which is electrically fused, has a greater presence of metallic impurities, limiting its UV transmittance wavelength to around 250 nm, but a much lower water content, leading to excellent infrared transmission up to 3.6 μm wavelength. All grades of transparent fused quartz/fused silica have near-identical physical properties.

The water content (and therefore infrared transmission of fused quartz and fused silica) is determined by the manufacturing process. Flame fused material always has a higher water content due to the combination of the hydrocarbons and oxygen fuelling the furnace forming hydroxyl [OH] within the material. An IR grade material typically has an [OH] content of <10 parts per million.

Typical properties of clear fused quartz

- Density: 2.203 g/cm^3
- Hardness: 7 (Modified Scale); 5.3–6.5 (Mohs Scale)
- Tensile strength: 48.3 MPa
- Compressive strength: >1.1 GPa
- Bulk modulus: ~37 GPa
- Rigidity modulus: 31 GPa
- Young's modulus: 71.7 GPa
- Poisson's ratio: 0.16
- Coefficient of thermal expansion: 5.5×10^{-7} cm/(cm·K) (average from 20 °C to 320 °C)
- Thermal conductivity: 1.3 W/(m·K)
- Heat capacity: 45.3 J/mol
- Softening point: c. 1665 °C
- Annealing point: c. 1140 °C
- Strain point: 1070 °C
- Electrical resistivity: >10^{18} Ω×m
- Dielectric constant: 3.75 at 20 °C 1 MHz
- Dielectric loss factor: less than 0.0004 at 20 °C 1 MHz
- Index of refraction at 587.6 nm (n_d): 1.4585

See also

- Quartz
- Silica (fused silica hardness = 8-10 GPa)
- Vycor
- Glass
- List of minerals

Retrieved from "http://en.wikipedia.org/wiki/Fused_quartz"

Categories: Chemical engineering | Glass

Material Properties

Five Schott Glass Types

The following paragraphs list the most important optical and physical constants for Schott or glass types BK7, SF11, LaSFN9, BaK1, and F2. These types are used in most Melles Griot lens products and prisms. Index of refraction and transmission, as well as the most common required chemical characteristics and mechanical constants, are listed. Further numerical da more detailed discussion of the various testing processes can be found in the Schott Optical catalog.

The index of refraction data were obtained by using the constants listed below together with dispersion formula. The constants were determined through the index-of-refraction measure a typical melt for each glass type. Note that the dispersion formula is valid only within the wavelength range listed. It can be used to interpolate refractive index at other wavelengths v this range (to a precision of 1×10^{-5} or better), but it should not be used to extrapolate to wavelengths beyond this range. Furthermore, the actual melt-to-melt tolerance on the index refraction typically is about ±0.001.

BK7 Glass

Abbé Constant: 64.17

Density:2.51 g/cm^{-3}

Young's Modulus: 8.20×10^9 $dynes/mm^2$

Poisson's Ratio: 0.206

Coefficient of Thermal Expansion (-30° to +70°C): 7.1×10^{-6}/°C

Coefficient of Thermal Expansion (20° to 3000°C): 8.3×10^{-6}/°C

Stress Birefringence, (Yellow Light): 10 nm/cm

Homogeneity within Melt: $\pm 1 \times 10^{-4}$

Striae Grade (MIL-G-174-A): A

Transformation Temperature: 557°C

Climate Resistance: 2

Stain Resistance: 0

Acid Resistance: 1.0

Alkali Resistance: 2.0

Phosphate Resistance: 2.3

Knoop Hardness: 610

Dispersion Constants:

$B_1 = 1.03961212$

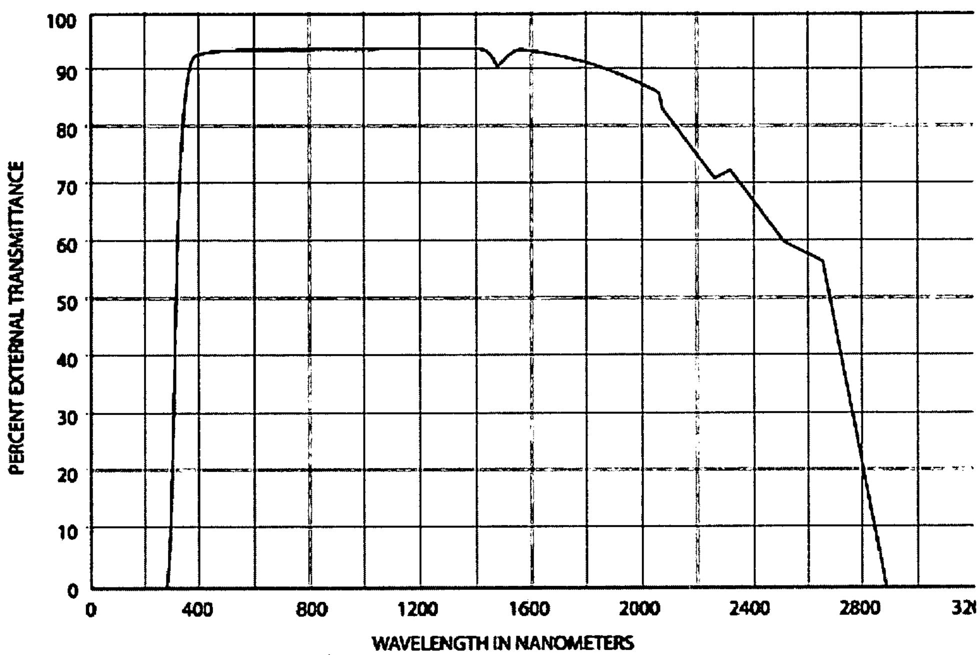
$B_2 = 2.31792344 \times 10^{-1}$

$B_3 = 1.01046945$

$C_1 = 6.00069867 \times 10^{-3}$

$C_2 = 2.00179144 \times 10^{-2}$

$C_3 = 1.03560653 \times 10^{2}$



External transmission for 10-mm-thick BK7 glass

Physical Constants of BK7 Glass

Wavelength (nm)	Refractive Index *n*	Fraunhofer Designation	Source	Spectral Region
351.1	1.53894	--	Ar laser	UV
363.8	1.53649	--	Ar laser	UV
404.7	1.53024	h	Hg arc	Violet
435.8	1.52668	g	Hg arc	Blue
441.6	1.52611	--	HeCd laser	Blue
457.9	1.52461	--	Ar laser	Blue
465.8	1.52395	--	Ar laser	Blue
472.7	1.52339	--	Ar laser	Blue
476.5	1.52309	--	Ar laser	Blue
480.0	1.52283	F'	Cd arc	Blue

486.1	1.52238	F	H_2 arc	Blue
488.0	1.52224	--	Ar laser	Blue
496.5	1.52165	--	Ar laser	Green
501.7	1.52130	--	Ar laser	Green
514.5	1.52049	--	Ar laser	Green
532.0	1.51947	--	Nd laser	Green
546.1	1.51872	e	Hg arc	Green
587.6	1.51680	d	He arc	Yellow
589.3	1.51673	D	Na arc	Yellow
632.8	1.51509	--	HeNe laser	Red
643.8	1.51472	C'	Cd arc	Red
656.3	1.51432	C	H_2 arc	Red
694.3	1.51322	--	Ruby laser	Red
786.0	1.51106	--	--	IR
821.0	1.51037	--	--	IR
830.0	1.51020	--	GaAlAs laser	IR
852.1	1.50980	s	Ce arc	IR
904.0	1.50893	--	GaAS laser	IR
1014.0	1.50731	t	Hg arc	IR
1060.0	1.50669	--	Nd laser	IR
1300.0	1.50370	--	InGaAsP laser	IR
1500.0	1.50127	--	--	IR
1550.0	1.50065	--	--	IR
1970.1	1.49495	--	Hg arc	IR
2325.4	1.48921	--	Hg arc	IR

SF11 Glass

Abbé Constant: 25.76

Density: 4.74 g/cm^{-3}

Young's Modulus: 6.60 x 10^9 dynes/mm^2

Poisson's Ratio: 0.235

Coefficient of Thermal Expansion (-30° to +70°C): 6.1 x 10^{-6}/°C

Coefficient of Thermal Expansion (20° to 3000°C): 6.8 x 10^{-6}/°C

Stress Birefringence, (Yellow Light): 10 nm/cm

Melt-to-Melt Mean Index Tolerance: ±0.001

Homogeneity within Melt: ±1 x 10^{-4}

Striae Grade (MIL-G-174-A): A

Transformation Temperature: 505°C

Climate Resistance: 1

Stain Resistance: 0

Acid Resistance: 1.0

Alkali Resistance: 1.2

Phosphate Resistance: 1.0

Knoop Hardness: 450

Dispersion Constants:

B_1 = 1.73848403

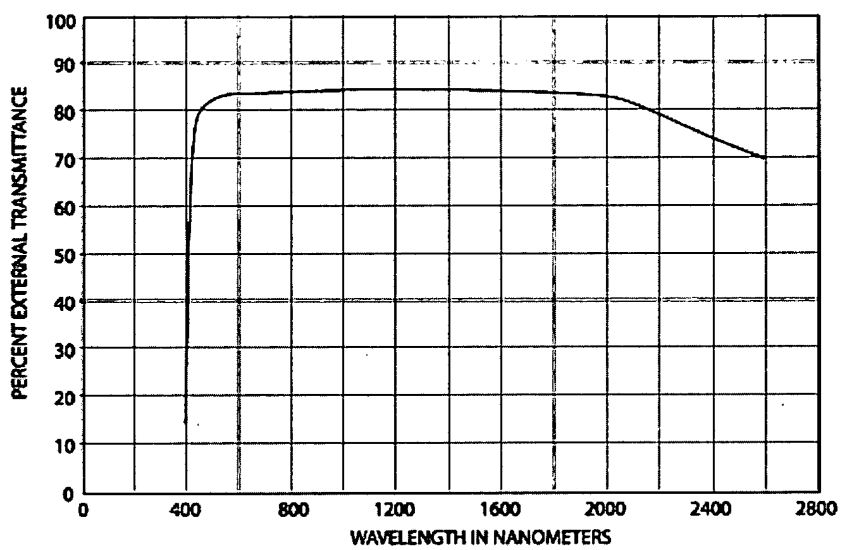
B_2 = $3.11168974 \times 10^{-1}$

B_3 = 1.17490871

C_1 = $1.36068604 \times 10^{-2}$

C_2 = $6.15960463 \times 10^{-2}$

C_3 = 1.21922711×10^{2}



External transmission for 10-mm-thick SF11 glass

Physical Constants of SF11 Glass

Wavelength (nm)	Refractive Index n	Fraunhofer Designation	Source	Spectral Region
404.7	1.84208	h	Hg arc	Violet
435.8	1.82518	g	Hg arc	Blue
441.6	1.82259	--	HeCd laser	Blue
457.9	1.81596	--	Ar laser	Blue
465.8	1.81307	--	Ar laser	Blue
472.7	1.81070	--	Ar laser	Blue

476.5	1.80946	--	Ar laser	Blue
480.0	1.80834	F'	Cd arc	Blue
486.1	1.80645	F	H_2 arc	Blue
488.0	1.80590	--	Ar laser	Blue
496.5	1.80347	--	Ar laser	Green
501.7	1.80205	--	Ar laser	Green
514.5	1.79880	--	Ar laser	Green
532.0	1.79479	--	Nd laser	Green
546.1	1.79190	e	Hg arc	Green
587.6	1.78472	d	He arc	Yellow
589.3	1.78446	D	Na arc	Yellow
632.8	1.77862	--	HeNe laser	Red
643.8	1.77734	C'	Cd arc	Red
656.3	1.77599	C	H_2 arc	Red
694.3	1.77231	--	Ruby laser	Red
786.0	1.76558	--	--	IR
821.0	1.76359	--	--	IR
830.0	1.76311	--	GaAlAs laser	IR
852.1	1.76200	s	Ce arc	IR
904.0	1.75970	--	GaAs laser	IR
1014.0	1.75579	t	Hg arc	IR
1060.0	1.75445	--	Nd laser	IR
1300.0	1.74901	--	InGaAsP laser	IR
1500.0	1.74554	--	--	IR
1550.0	1.74474	--	--	IR
1970.1	1.73843	--	Hg arc	IR
2325.4	1.73294	--	Hg arc	IR

LaSFN9 Glass

Abbé Constant: 32.17

Density: 4.44 g/cm^{-3}

Young's Modulus: 1.09 x 10^{10} dynes/mm^2

Poisson's Ratio: 0.286

Coefficient of Thermal Expansion (-30° to +70°C): 7.4 x 10^{-6}/°C

Coefficient of Thermal Expansion (20 °to 3000°C): 8.4 x 10^{-6}/°C

Stress Birefringence, (Yellow Light): 10 nm/cm